AN ABSTRACT OF THE THESIS OF

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Title: Seasonal Movements and Habitat Use of Migratory Elk
in Mount Rainier National Park.

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Edward E. Starkey

Seasonal movements, habitat use, home range selection, and group interactions of Roosevelt elk (Cervus elaphus roosevelti) were studied in the upper White River watershed in west-central Washington. Over 2000 locations of 14 elk were recorded by radio-telemetry from April 1983 to December 1984.

During winter, two herds used clearcut lands near the mouth of the West Fork of the White River (about 610m MSL). One herd migrated four km to a clearcut spring range at 1070m MSL, whereas the other remained on the winter range during spring. Both herds migrated 15 km up river corridors to subalpine parklands within Mount Rainier National Park where they remained from July to October.

A third herd wintered in unmanaged old-growth forest within Mount Rainier National Park along bottomlands of the White River Valley (915m MSL). That herd then moved 5-10 km upriver toward summer range during June, and arrived on subalpine summer range the first week in July. All herds migrated back to winter ranges via river corridors following heavy snowfall on November 15, 1983 and October 15, 1984.

Winter ranges of elk in both the managed and unmanaged segments of the study area were oriented along the valley floodplain. Consequently, ranges of elk in the managed forest contained greater proportions of old-clearcuts (12-30 years) and alder habitats (which occurred primarily on the floodplains) than existed in the valley. Preferred old-clearcut habitats contained a mosaic of dense, regenerating douglas-fir interspersed with open-canopied foraging areas. Old-growth and young clearcuts, which were located primarily on upland sites, were underrepresented in elk home ranges compared to their availability in the valley. Elk were generally unselective of habitats within the home range.

On the spring range of one herd, mid-age clearcuts (4-12 years) and young clearcuts (0-4 years) occurred in a greater proportions than in the valley. Preferred habitats contained many mesic seeps and draws. Spring range in the unmanaged forests consisted of old-growth valley bottom habitats.

Habitat preferences of elk varied between two summer ranges within Mount Rainier National Park. In general, elk preferred open subalpine forests, *Abies lasiocarpa/Valeriana sitchensis* habitat, and alder slide habitats. Additionally, Dry Grass, and Lush-low Herbaceous habitats tended to be used in proportions greater than availability.

SEASONAL MOVEMENTS AND HABITAT USE OF MIGRATORY ELK IN MOUNT RAINIER NATIONAL PARK

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To all those who helped me, this thesis is dedicated to you.

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SEASONAL MOVEMENTS AND HABITAT USE OF MIGRATORY ELK IN MOUNT RAINIER NATIONAL PARK

I. INTRODUCTION

Prior to settlment by European man, Roosevelt elk (*Cervus elaphus roosevelti*) were distributed widely throughout western Oregon and Washington (Starkey *et al.* 1982). However, accounts of the Mount Rainier area by early white visitors, explorers, and climbers mentioned elk only rarely. Elk numbers were considered low throughout the Pacific Northwest in the mid 1800's (Gustafson 1984), but it is unknown whether failure to observe elk in the Mount Rainier area was related to the regional trend, or other local limiting factors.

After the Mount Rainier area was settled by European man, elk numbers likely were further reduced by hunting throughout western Oregon and Washington (Starkey *et al.* 1982). Protection from hunting, reintroductions of elk, natural recolonization, and in some cases logging, have benefitted elk since the 1920's. A large and growing elk population now occupies the White River Valley north of Mount Rainier National Park during winter and migrates to the subalpine areas within the park during summer (Cooper 1984). Those elk are probably genetically related to 36 Rocky Mountain elk (*Cervus elaphus nelsoni*) purchased from Yellowstone National Park and released near Enumclaw, Washington in 1913. Additional reintroductions of elk in the nearby Green

River and Yakima basins may have also contributed to the current gene pool of elk in the White River Valley. However, morphometric (Schoenwald-Cox _et al._ 1985) and electrophoretic (Dratch 1983) analyses of genetic variations between Roosevelt elk and Rocky Mountain elk do not support subspecific designations.

Research on the relationship between elk populations and timber management in the Northwest is scant. Swanson (1970) and Harper (1985) investigated elk ecology on the Millicoma Tree Farm in western Oregon. Swanson found the greatest use of clearcuts 5-9 years after logging. Harper discussed use of clearcuts as a function of stand age, debris treatment, logging methods, habitat type, aspect, steepness, and distance to water and cover, and found that elk use was highest along clearcut/forest ecotones. Witmer (1981) examined daily and seasonal habitat use by Roosevelt elk in the southern Oregon Coast Range. He found that elk preferred old-growth and hardwood forests over mixed forests and dense young conifer stands. Brushy clearcuts were used more than new clearcuts for foraging but use of new clearcuts increased throughout the winter. Elk preferred southern exposures, avoided roads, and remained near forest edges. Witmer suggested that cover type, adjacent cover type, and aspect were the most useful parameters for the prediction of habitat use.

Few studies have examined habitat relationships and movement patterns of migratory Roosevelt Elk, perhaps because they are not migratory over much of their range. Schoen (1977) investigated habitat use of introduced, migratory elk in the Cedar River

Watershed 30 km north of Mount Rainier. He found that elk preferred 5-15 year old clearcuts in the *Tsuga heterophylla* forest zone during winter, as well as second-growth deciduous forests, riparian, wetland, and meadow habitats at low elevations. These elk avoided old-growth habitats during winter, and preferred 12-24 year old clearcuts in *Abies amabilis* forests during summer at elevations between 610 - 1220m MSL.

Youds *et al.* (1985) described migratory and non-migratory herds of elk on Vancouver Island, British Columbia. They found that elk preferred bogs, rocky areas, deciduous stands, and 20-60 year-old second-growth during winter, whereas they avoided 0-20 year-old second-growth and 20-40 year-old spaced second-growth. Schroer (1986) studied migratory Roosevelt elk that wintered in the Duckabush and Dosewallips drainages on the east side of the Olympic Peninsula, Washington, and migrated to subalpine areas within Olympic National Park. Those elk preferred seral deciduous or deciduous/coniferous forests (< 150 years-old) on low elevation winter range, and selected a mosaic of subalpine meadows and conifer patches on summer range. Bradley (1982) described migration patterns and distribution of elk in the subalpine zone of Mount Rainier National Park, but he did not discuss use of silviculturally managed winter range.

Factors influencing social behavior of Roosevelt elk are poorly understood. Franklin *et al.* (1975) Franklin and Lieb (1979), and Jenkins and Starkey (1982) studied herd dynamics in sedentary populations of Roosevelt elk. Those studies suggested that herds occupying undisturbed habitats are more cohesive, and form more stable social units than those inhabiting managed landscapes. Similar studies of migratory Roosevelt elk have not been conducted. However, Craighead et al. (1973) and Knight (1970) found that migratory Rocky Mountain elk herds were relatively unstable and rarely formed lasting associations.

The purpose of this study was to describe habitat use, seasonal movements, and social group interactions of migratory elk wintering in the White River drainage north of Mount Rainier National Park.

Specific objectives were to describe:

a: Seasonal movements and home ranges.

b: Habitat characteristics of home ranges in relation to available habitats within the White River Valley.

c: Habitat use within home ranges.

d: Spatial relationships between and within herds.

This information will help assess potential impacts of forest management practices on Mount Rainier elk populations, and will document elk habitat use patterns of subalpine ranges in the Cascade mountains for the first time.

II. STUDY AREA

Location

The study area encompasses the upper White River watershed in west-central Washington (Fig. 1). The White River originates from the Emmons Glacier on Mount Rainier. Thus, high elevation summer range is included within Mount Rainier National Park. Upon leaving the northeast corner of the park, the White River flows northward through elk winter range on U. S. Forest Service and private lands. Crystal Village, a small development of about 30 houses, is situated on the floodplain about 12 miles north of the park boundary and in the winter range.

Climate

Mount Rainier lies within the temperate maritime climatic region. Climate is generally cool and moist, with wet, mild winters and relatively dry, cool summers. The study area is in the rainshadow of Mount Rainier's northeast slope, and is dry relative to the rest of the park. Sixty inches of precipitation fall on the winter range annually. The upper reaches of the White River (summer range) receive 80 to 90 inches of precipitation annually. Ninety percent of this precipitation falls between November and April; mostly as snow which remains until late July at higher elevations.

Historical weather records were available for the period 1939 - 1980 (Table 1) from a weather station near the elk winter range at Greenwater, Washington. During that period, average winter

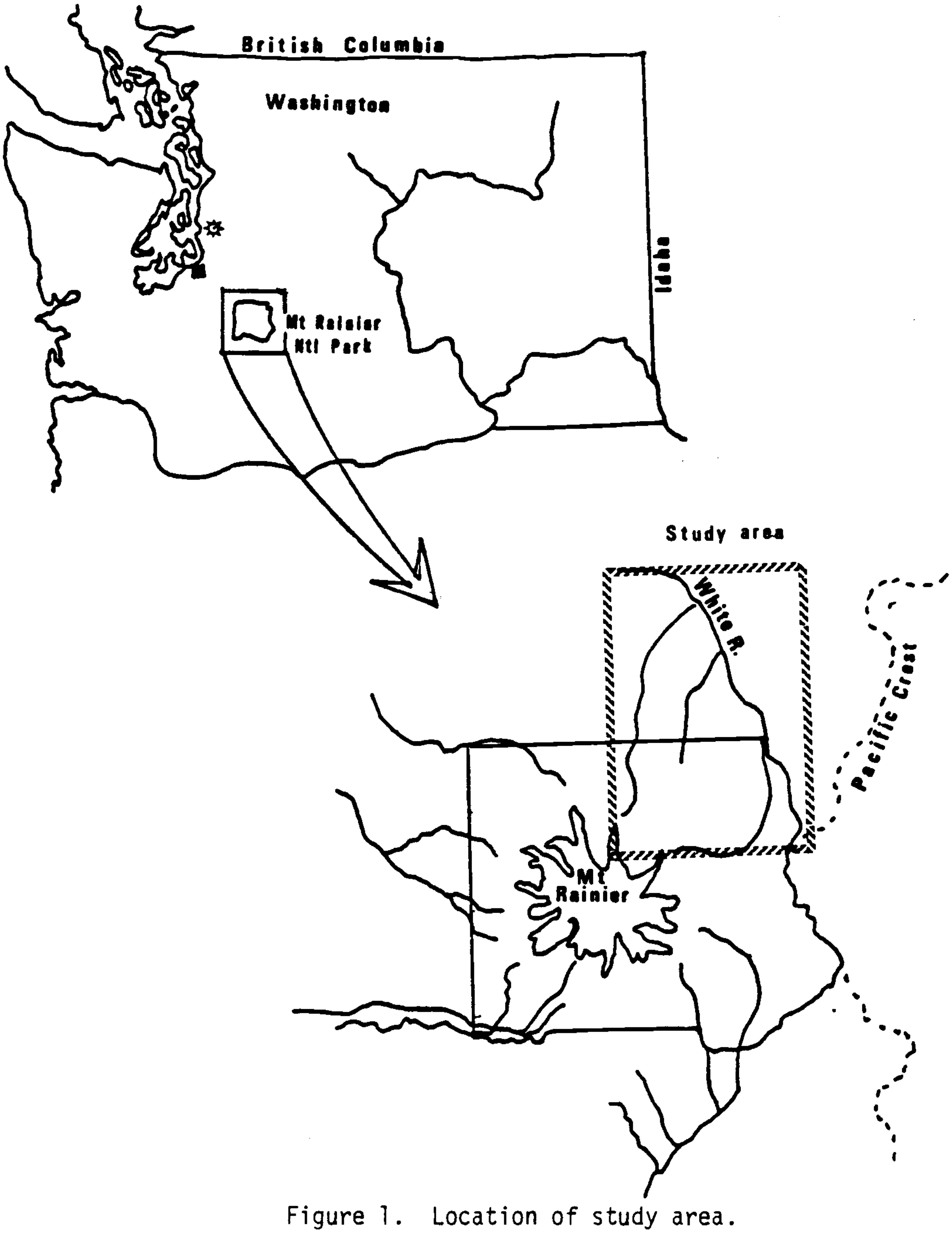

Figure 1. Location of study area.

temperatures ranged from the low to upper 30's, with January being the coldest month. Maximum snow depth averaged about three inches in November to 20 inches in January. Heavy snows occurred twice in this time. Six feet of snow lay on the ground in February, 1949, whereas five feet accumulated during 1950. Since 1950, winter temperatures and snow depths have been average or less than average except for January and February of 1957, 1959, and 1969, when nearly three feet of snow accumulated.

During the study period (1983-1984) temperatures were consistent with the long-term averages, but snow depths, which never exceeded eight inches, were less than normal. The summer of 1983 was extraordinarily wet and cool possibly because of El Nino, whereas the summer of 1984 was average.

Physiography and Vegetation

Elevations of the study area range from 610 - 1980m MSL. The alpine zone lies above 6000 feet MSL within Mount Rainier National Park. Steep terrain, bare rock and ice, low krumholz vegetation, and a very short growing season characterize this zone. The subalpine zone lies between 4000' and 6000'. Very steep, dissected ridges and associated cirques are common features of the subalpine zone. Snow may remain on north facing slopes until early August. The coniferous forest zone extends from about 5000' downslope to glacially carved valleys of the White River, Huckleberry Creek, and the West Fork of the

Table 1. Synopsis of weather patterns for winter months in Greenwater Washington from 1939-1980. Taken from U.S. Dept of Commerce Climatological Data, National Climatic Center, Asheville, North Carolina. Temperature in degree Fahrenheit and snowfall depth in inches.

41 year Average of:	MONTH NOV.	DEC.	JAN.	FEB.	MARCH
Temperature	38.6	33.6	31.4	36.4	38.8
Daily Minimum Temperature	19.6	16.3	10.1	18.4	20.3
Total snowfall (range)	5.4" (0-24)	16.4" (0-80)	24.0" (0-99)	13.8" (0-62)	12.5" (0-48)
Maximum snow depth (range)	2.7" (0-12)	10.4" (0-40)	19.5" (0-54)	15.0" (0-69)	11.8" (0-41)

White River. Steep, forested slopes encase these narrow watercourses. The floodplain of the White River Valley broadens to a width of two miles at the confluence of the main and West Forks of the White River.

Sublapine vegetation consists of scattered pockets of subalpine fir (*Abies lasiocarpa*) interspersed with lush meadows. Classification of subalpine meadow vegetation types was based on Henderson (1974), who classified and mapped seven vegetation types (Table 2).

The coniferous forest zone is dominated by climax *Tsuga heterophylla-Thuja plicata* forest communities (Franklin and Dyrness 1973), Franklin *et al.* (1979) classified the unmanaged old-growth forests of the valleys within Mount Rainier National Park (Table 3). These old-growth forests had a dense canopy and an understory varying from open and parklike to dense thickets of salal (*Gaultheria shallon*), vine maple (*Acer circinatum*), and alder (*Alnus rubrus*). Alluvial gravel bars and avalanche openings were interspersed within the forest.

Bottomlands along the White River, West Fork of the White River, and Greenwater River north of Mount Rainier National Park are managed by the USDA Forest Service, State of Washington Department of Natural Resources, and Weyerheauser Company. The majority of bottomland forests was progressively clearcut for timber production from 1950 to 1970. Elk winter home ranges outside of the park occur mostly within these clearcuts. Some old-growth still remains in the uplands and along roads and streams north of the park.

Table 2. Characteristics of Subalpine Vegetation Types in Mt. Rainier National Park (modified from Henderson, 1974).

Vegetation Type	Elevation	Dominant Understory Species
HEATH	5200-7000'	Lupinus latifolius Phyllodoce empetriformis Cassiope mertensiana Vaccinium deliciosum
DRY GRASS	varied	Festuca viridula
LUSH HERBACEOUS	low elevation	Lupinus latifolius Valeriana sitchensis Polygonum bistortoides Carex spectabilis
WET SEDGE	varied	Carex nigricans Carex spectabilis Antennaria lanata Pedicularis groenlandicum
LOW HERBACEOUS-LUSH HERBACEOUS	varied	Aster alpigenus Antennaria lanata
OPEN SUBALPINE WOODS	timberline	Abies lasiocarpa Valeriana sitchensis Festuca viridula Lupinus latifolius
SHRUB	varied	Spiraea densiflora

Table 3. Characteristics of unmanaged vegetation types in the coniferous forest zone in Mt. Rainier Nat'l. Park (modified from Franklin, _et al._ 1979). Acronyms are identified in table 6.

VEG.TYPE	ELEV.	TEMP. MOIST. CLASS	DOMINANT SPECIES			ASSOCIATED LANDFORMS
			Tree	Shrub	Herb	
Abam/Bene	3000- 4500'	Dry	Psme Tshe	Acci Bene	Chum Actr	Dry Slopes
Abam/Gash	2980- 4300'	Dry	Psme Tshe	Gash Xete	Chum Libo	Moderate to steep slopes
Abam/Xete	4600- 4950'	Dry	Tshe Abam	Vame Xete	Pyse Libo	Steep slopes & ridges
Psme/Aruv	3000'	Dry	Psme Pico	Vaal Vaov	Libo Coca	Slopes & ridges
Tshe/Gash	1840- 3300'	Dry	Psme Tshe	Acci Tabr	Chum Libo	Dry slopes & ridges
Abam/Vaal	3000- 4425	Modal	Abam Tshe	Vaal	Libo	No extremes
Bene	2080- 3087'	Modal	Psme Tshe	Vapa Bene	Chum	Valley bottoms
Chno	2000- 3000'	Modal	Psme Tshe	Chno Bene	Chum Libo	Valley bottoms
Rupe	2790- 4570'	Modal	Tshe Abam	Vaal Voav	Libo Coca	Valley bottoms
Abam/Opho	2160- 3900'	Moist	Thpl Abam	Rusp Opho	Gydr Actr	Valley bottoms
Abam/Tiun	2740- 4900'	Moist	Abam Abpr	Acci Vame		Slopes
Alru/Rusp	3000'	Moist	Alru	Acci Opho	Gydr Actr	Valley bottoms
Tshe/Actr	1820- 2310'	Moist	Psme Tshe	Acci Bene	Actr Visa	Valley bottoms
Tshe/Pomu	2000- 2800'	Moist	Psme Tshe	Bene Acci	Titr	Slopes
Abam/Mefe	3580- 4880'	Cold	Abam Tshe	Mefe Vame	Rupa	High elevation

Table 3. (cont.)

VEG.TYPE	ELEV.	TEMP. MOIST. CLASS	DOMINANT SPECIES Tree	Shrub	Herb	ASSOCIATED LANDFORMS
Abam/Rhal	4000- 5340	Cold	Abam Tsme	Rhal Vame	Ermo Rula	Upper slopes
Abam/Rula	4300- 5700'	Cold	Abam Tsme	Vame Rhal		Ridgetops
Ermo	4380- 5440'	Cold	Abam Tsme	Vame	Ermo Rula	Upper slopes & ridgetops
Rula	4290- 5760'	Cold	Abam Chno	Vame Rula		Mountain slopes & ridgetops
Abla/Vasi	4940- 5650'	Cold	Abla Psme	Vame Rula		Upper slopes & ridgetops

Table 4. Characteristics of managed forest vegetation types north of Mt. Rainier Park.

VEGETATION TYPE	AGE	TREE HEIGHT	SPECIES	UNDERSTORY
Young clearcut	0-4 yrs	0-2 m	*Pseudotsuga menziesii*	Undeveloped except in older & wetter sites
Mid-age clearcut	4-12 yrs	2-4 m	*Abies procera* *Psuedotsuga menziesii* *Tsuga heterophylla*	Well developed in younger stands. Poor in older stands exept where wet. Early greenup.
Old clearcut	12-30 yrs	4-15 m	*Psuedotsuga menziesii* *Tsuga heterophylla*	Poorly developed except in numerous open areas 2-10 m in diameter.
Old-growth	150+	15 m+	(see Franklin *et al.* 1979)	Variable
Alder	20-30 yrs	5-8 m	*Alnus rubrus*	Mesic. Often poor shrub developement Moderate to dense herbaceous cover.
Open swampy meadow	Variable		Trees absent	Mesic to hydric. Dominated by Carex spp.
Cottonwood	40-60 yrs	10-20 m	*Populus trichocarpa* *Pseudotsuga menziesii* *Alnus rubrus*	Deep leaf litter. Variable shrub and herbaceous layers.

III. METHODS

Capture Procedures

Twenty cow elk were radio-collared in the White River drainage during winter and spring of 1981 and 1982. Elk were captured in two Oregon style corral traps (Mace 1971) baited with alfalfa. One more collar was placed on a trapped cow elk near the north boundary during March, 1984.

Elk were immobilized after capture using 16-23 mg of powdered succinylcholine chloride administered in pre-loaded Pneu-darts (Liscinsky, et al. 1969). Elk were fitted with radio-collars equipped with 164 Mhz transmitters manufactured by Telonics, Inc. Life expectancy of transmitter batteries was approximately 36 months, but several transmitted for over 48 months.

Radio-Telemetry Procedures

Radio-collared elk were relocated systematically from April, 1983 to January, 1985. During winter (fall migration to spring migration), elk were located once daily. During the spring (spring migration to summer migration) and summer (summer migration to winter migration), when the elk were in the backcountry, one to three locations per elk per week were obtained.

Radio-collared elk were located remotely using a Telonics T2 receiver and a two-element hand-held Yagi antenna. Several receiving stations were established along major drainages and ridges. Locational bearings were obtained by rotating the antenna to find the strongest signal, then by reducing the gain and finding the null on either side of the peak signal. Azimuths were recorded as the vector bisecting that angle. Two to four such azimuths were recorded for each elk and were drawn on United States Geological Survey maps (1:24,000) that were gridded using a 100m x 100m Universal Transverse Mercator (UTM) system. A circle was inscribed in the polygon formed by the intersection of multiple azimuths and the UTM grid coordinates of the circle's center were recorded. Telemetry receiving stations were chosen such that the angle of intersection between azimuths was approximately 90 degrees to minimize the effect of telemetry error on location estimates.

Preliminary testing for telemetry accuracy was accomplished by randomly locating transmitters in both old-growth forests and clearcuts at different distances from telemetry stations. Because accuracy decreased with distance, readings were rejected at distances greater than 0.6 km in old growth forests and second growth, and greater than 1 km in clearcuts or open subalpine meadows. Those distances were associated with error polygons larger than mapped grid cells (100m x 100m). Distance from locations was determined by triangulation in the field, radio signal strength, and previous knowledge of topography and elk habits. Readings were also rejected when directional vectors did not converge. In cases of rejection, the elk was approached more closely to obtain a reliable radio-location. On the winter range this was not difficult due to the extensive road system. Elevations and habitat classifications of acceptable elk locations were obtained from topographic and vegetation maps and recorded.

Home Range and Movements

Home range was defined as the area used by a non-juvenile animal during the course of its daily activities (Burt 1943). Migratory routes were not considered part of the seasonal home ranges. Methods to describe home ranges from telemetry or trapping data include circular (Burge and Jorgensed 1973, Calhoun 1963, and Metzgar 1973), elliptical (Jenrich and Turner 1969, Koepple et al. 1975), and polygon models (Southwood 1966). These techniques do not account for physical barriers to elk travel such as cliffs or water bodies. Consequently, unavailable range areas may be included within the home range estimate.

An alternative description of elk home ranges utilizes contours based on harmonic mean values of grid points superimposed on the home range (Samuel *et al*. 1983). The harmonic mean is the reciprocal of the arithmetic mean of the reciprocals of distances to each location from each grid point. The greater the harmonic mean of a grid point, the farther it is from the center of activity. Contours are drawn around points which have specified proportions of the total range of harmonic mean values. In this study, home ranges were delineated for analyses of elk distribution and habitat use using a 75% harmonic mean contour. That method best represented areas actually used by elk, and was only slightly influenced by outlying points.

Sizes of home ranges were determined as the area within the minimum convex polygon calculated after outliers were deleted (Samuel *et al.* 1983). This technique was used to allow comparisons of home range size in other studies.

Average daily movements of elk were determined by summing the straight line distances between daily locations and dividing it by the elapsed number of 24 hour periods. Most locations were obtained between 9:00 am and 4:00 pm. It was assumed that time intervals between daily locations averaged 24 hours.

Home range size and average daily movements of individual elk were compared between 1983 and 1984 (appendix 2) using a Student's t-test (Dixon and Massey 1969). No significant differences were found between years so the annual data were combined for further analyses. ANOVA and Duncan's multiple range tests were used to compare home range size and average daily movements among three seasons within each herd and between herds each season.

Habitat Use Analysis

Johnson (1980) identified hierarchical levels of habitat selection. First, animals select a home range within their greater geographical range. Secondly, animals select habitats within their home range. Animals also choose foraging patches and plants within habitats and specific parts within a plant. The first two levels provide the conceptual framework for analysis of habitat use in this study.

To determine if habitat composition influenced home range selection, composition of habitats within the winter home ranges was compared with that which existed in the valley as a whole. The area available for winter home range selection was determined from limiting (>1m) snow depths and general observations of geographical limits to elk winter distribution. Statistical comparisons of habitat composition within home ranges with that within the valley were not feasible because the two data sets were not independent; habitats in the home ranges comprise a portion of habitats in the valley. Discrepancies between proportions of habitats in the valley and home ranges were evaluated subjectively. Selection of summer home ranges was not analyzed because of difficulty in delimiting the area of total available habitat.

Use of habitats by radio-collared elk was evaluated relative to availability inside the composite 75% harmonic mean home range. Analyses were based on locations of individual elk, and pooled locations of elk in each herd. Composite home ranges were derived from pooled locations of elk. Chi-square tests of independence and Bonferonni confidence intervals (Neu *et al.* 1974) were used to determine which habitats were used significantly greater than their availability (selection) or less than their availability (avoidance) within the home range. Habitat selection was analyzed separately each year (appendix 3).

Social Group Interactions

Two methods were used to describe the spatial relationships between individual elk within each herd. A coincidence index (CI), reviewed by Cole (1949:415), was used to examine the frequency with which each pair of radio-collared elk was observed in the same herd. That index was computed as CI = 2(AB)/A+B where AB = number of times A and B were located together, and A and B = total individual number of times each elk was located. For this study, elk were considered to be in the same herd if they were located within 400 meters of each other. Values of the indices range from 0, indicating no association, to 1.0, indicating perfect association.

Coincidence indices were computed to permit comparisons with previously published work. However, coincidence indices are relatively insensitive indicators of cohesiveness. To overcome this insensitivity, average distances between pairs of elk were compared for herds in managed forests and herds in unmanaged forests on this study area (appendix 1). Only this latter technique was used for statistical analysis because it did not require an arbitrary determination of association between pairs of elk and because it allowed the use of parametric statistics in the analysis of association among individuals and herds.

Average distances between elk did not differ between 1983 and 1984, and thus were pooled. ANOVA and Duncan's multiple range tests were used to compare the average distance between all collared elk in a herd from one season to the next. The same test was used to compare the average distance between all elk in one herd to the average distance between all elk in other herds during each season.

IV. RESULTS

Annual Movements and Distribution

Three separate herds were identified and named after prominent geographical features on the winter range (Figs. 2,5). The Crystal Village herd wintered in clearcut floodplain forests of the main stem and the west fork of the White River near the Crystal Village subdivision. The Gold Hill herd wintered near Gold Hill about 1.5 miles northeast of the Crystal Village herd, near the confluence of the Greenwater and White Rivers. This area is also silviculturally managed. The North Boundary herd inhabited predominantly old-growth forests in the narrow floodplain of the White River near the Mount Rainier Park boundary during the winter. The Crystal Village herd was identified on the basis of seven radio-collared elk, whereas the Gold Hill and North Boundary herds contained two and five radio-collared elk, respectively.

Seasonal migration patterns were variable among the three herds. All three herds migrated from summer to winter range after the first heavy snowfall (November 15 in 1983 and October 15 in 1984). However, the Crystal Village herd also migrated about four km between May 20 and June 1 to a separate spring range. This spring range is located on the northernmost end of the crest of Huckleberry Ridge (Fig. 3). Up to 75 cows and calves were seen together there. Radio-collared elk in the Gold Hill and North Boundary herds did not exhibit a spring migration, and occupied their winter range until early July.

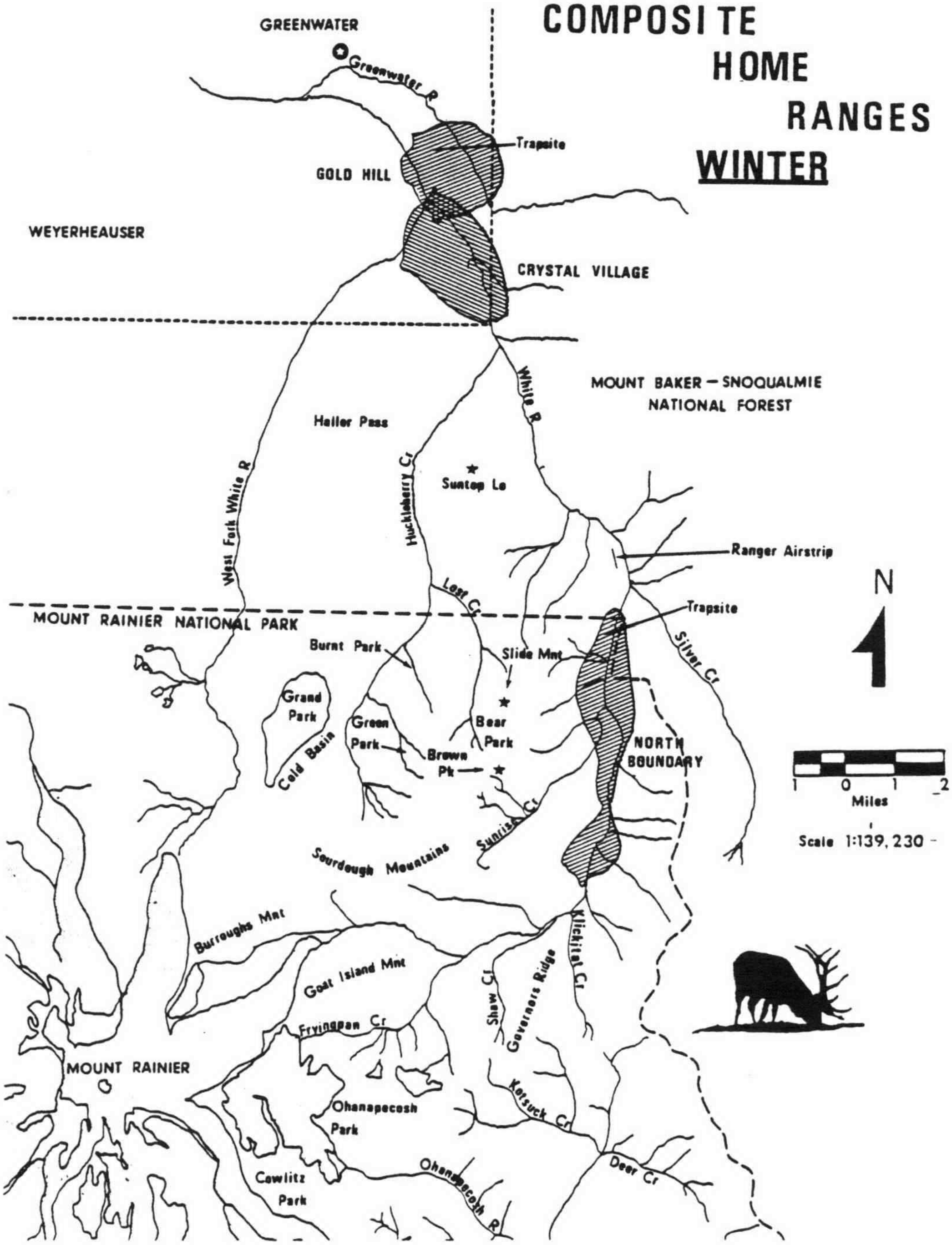

Figure 2. Composite Winter Home Ranges.

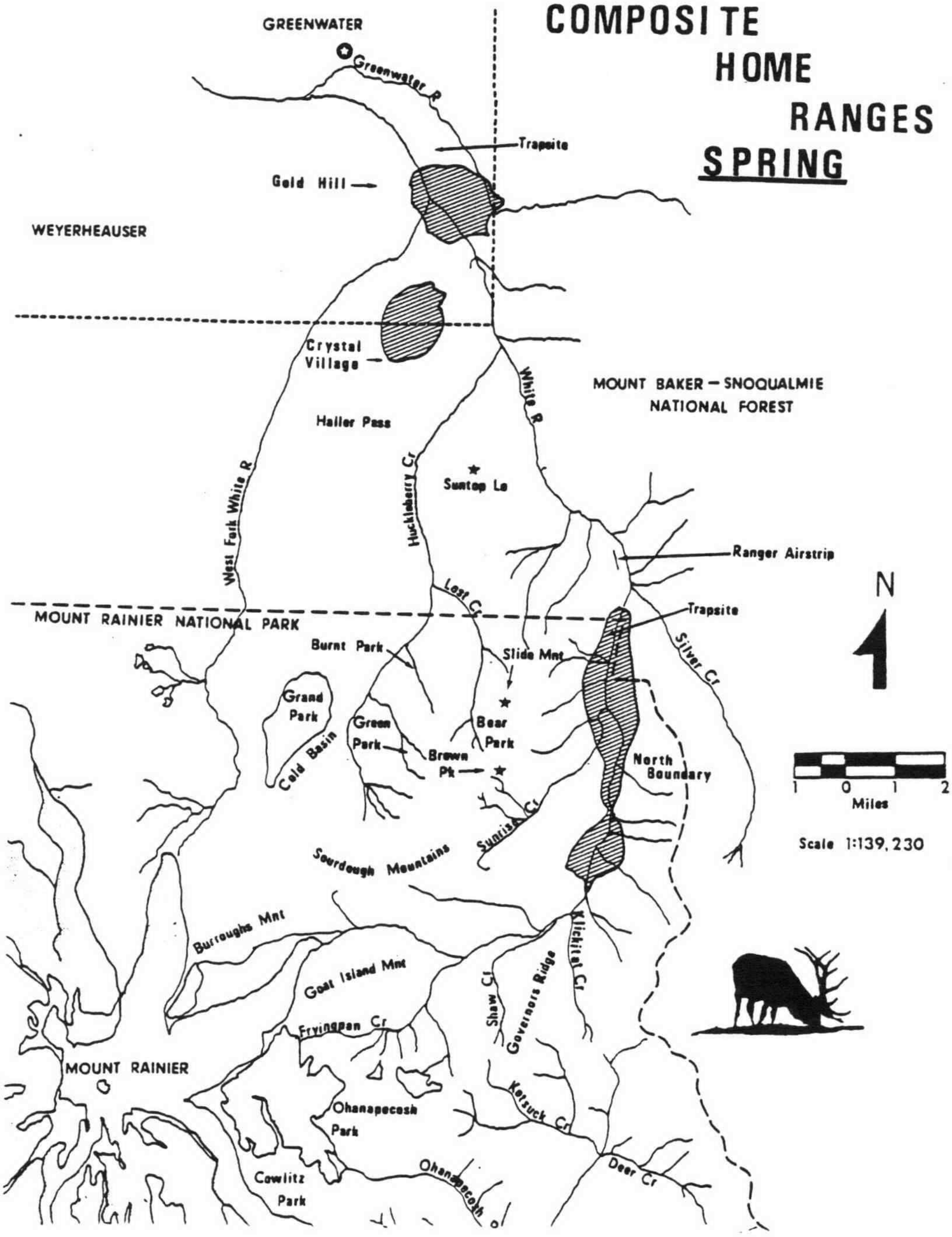

Figure 3. Composite Spring Home Ranges.

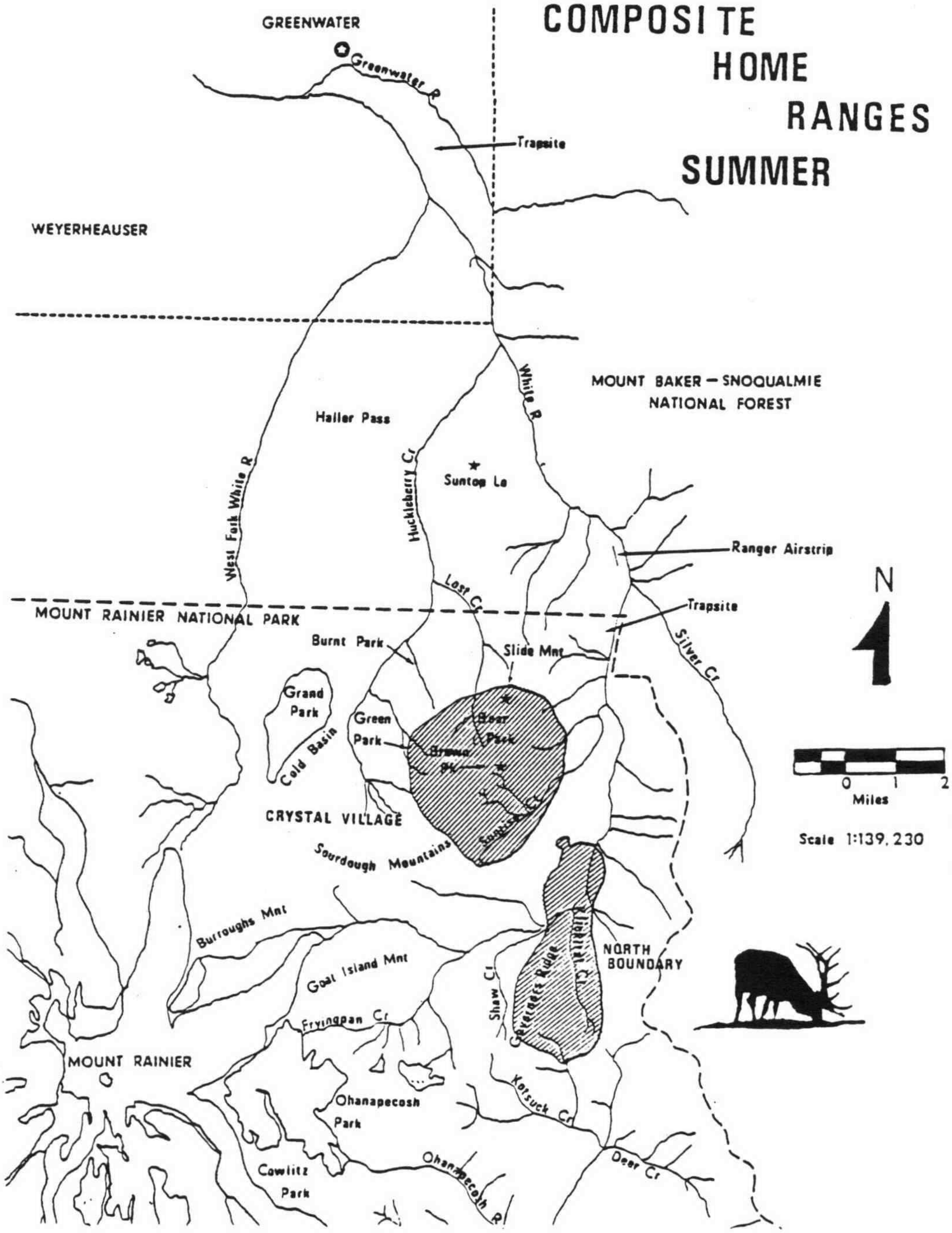

Figure 4. Composite Summer Home Ranges.

All radio-collared elk migrated from winter or spring ranges to summer range between July 5 to July 10. Crystal Village and Gold Hill herds moved 15 km by calf/cow units up Huckleberry Creek and Lost Creek and merged in the subalpine meadows near the Palisades in Mount Rainier National Park (Fig. 4). Five to ten feet of snow often covered much of the range but elk concentrated on snow-free south facing slopes. These elk were most commonly found in the east facing cirques from Brown Peak to Buck Lake during summer. Elk from the North Boundary Herd migrated 5-10 km up the White River and Klickitat Creek to Governor's Ridge (Fig. 4) from early June to early July. Their upward movements were interrupted with one to seven day stops in the bottom of avalanche chutes on Governor's Ridge. The rut began in early September and, following heavy snows of 2-3 feet, the elk returned immediately to their respective winter ranges.

Habitat Use Patterns

Winter Range

Elk of the Crystal Village herd were located on the level river bottom eighty-five percent of the time. The winter home range was at approximately 640m MSL. Home ranges contained a greater proportion of old clearcut and alder flat vegetation types but less old-growth or young clearcuts than existed in the study area (Table 5). When availability of vegetation types within home ranges was compared to use, elk used old clearcut, old-growth, alder, and cottonwood in proportion to their

Table 5. Availability and use of habitats within the watershed and composite home ranges of elk in winter, 1983 and 1984.

	Winter Range		Composite 1983 Home Range			Composite 1984 Home Range		
	Cover Type	% in Watershed	% Available	% Use[a]	(n)	% Available	% Use[a]	(n)
Crystal Village	Old Clearcut	35.2	55.0	57.7		63.3	70.0	
	Old-growth	31.9	14.1	9.3		9.5	7.9	
	Alder Flat	3.7	10.9	21.7		9.3	10.1	
	Mid-age Clearcut	9.6	13.9	4.1-		10.5	9.3	
	Young Clearcut	7.2	2.1	2.1	6	3.3	0.0	8
	Cottonwood Mix	1.0	1.8	5.2		2.5	0.7	
	Open Swampy Meadow	1.0	1.9	0.0		1.2	2.1	
	Cedar	0.1	0.5	0.0		0.3	0.0	
Gold Hill	Old Clearcut	35.2	74.4	54.4		74.4	66.7	
	Old-growth	31.9	2.8	27.3+		2.8	9.5	
	Alder Flat	3.7	14.5	13.6		14.5	14.3	
	Young Clearcut	7.2	4.5	4.5	2	4.5	4.8	2
	Cottonwood Mix	1.0	1.6	0.0		1.6	0.0	
	Open Swampy Meadow	1.0	2.1	0.0		2.1	4.7	
Old-growth North Boundary Habitat Types	Abam/Bene[b]	< 1.0	40.8	6.0-		31.9	8.7-	
	Abam/Tiun	3.7	20.1	28.3+		15.7	39.1+	
	Tshe/Gash	4.4	11.2	34.3+		28.1	27.2	
	Abam/Vaal	< 1.0	8.7	14.9		5.9	8.7+	
	Rock	1.8	6.5	0.0		3.9	0.0	
	Abam/Gasah	< 1.0	6.0	7.4	3	3.4	5.5	4
	Abam/Rula	< 1.0	0.1	0.0		3.4	2.2	
	Alru/Rusp	< 1.0	1.4	3.0		1.5	2.2	
	Abam/Opho	< 1.0	1.0	4.5		1.5	3.3	
	Tshe/Actr	< 1.0	N/A			1.5	0.0	
	Abam/Rhal	< 1.0	0.6	1.5		1.5	2.2	
	Abla/Vasi	< 1.0	N/A			1.0	0.0	
	Lush herbaceous	< 1.0	N/A			0.4	0.0	
	Abam/Xete	< 1.0	4.0	0.0		0.2	0.0	
	Abam/Mefe	< 1.0	N/A			0.1	1.0	

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[a] This value indicates preference (+), no selection, or avoidance (-), based on use vs. availability comparison using a Bonferonni Z interval.

[b] Scientific and common names of abbreviations found in Table 6.

availability and avoided young clearcuts, mid-age clearcuts, and cedar flats.

Gold Hill elk were located on the level floodplain sixty-seven percent of the time, and the elevation of the home range was approximatly 625m MSL. As in the Crystal Village home range, the Gold Hill home range contained a greater proportion of old-clearcut and alder flat habitat than existed in the valley. Within the home range, elk selected old-growth in 1983 (Table 5) but avoided the cottonwood mix vegetation type both years and the open swampy meadows in 1983. Elk used all other vegetation types in proportion to their availability.

North Boundary elk selected home ranges in the narrow floodplain of the upper White River Valley at an average elevation of 960m. Fifty percent of the locations were on the level floodplain bottom. All habitats in the home range were overrepresented due to the relative sparcity of these old-growth habitats in the valley as a whole. Within the home range, elk preferred Abam/Tiun and Abam/Vaal and Tshe/Gash in 1983 (Table 5.) Elk did not use Abam/Bene, rock, Tshe/Actr, Abla/Vasi, Lush Herbaceous, and Abam/Xete habitats, and used all other habitats in proportion to their availability.

Table 6. Abbreviations of scientific names of plants used to identify habitat types, and the associated scientific and common name.

Abbreviation	Scientific name	Common name
ABAM	Abies amabilis	Silver fir
ABLA	Abies lasiocarpa	Subalpine fir
ACCI	Acer circinatum	Vine maple
ACTR	Achlys triphylla	Vanillaleaf
ALRU	Alnus rubra	Red alder
ARUV	Arctostophylos uva-ursi	Bearberry
ALSI	Alnus sinuata	Sitka alder
BENE	Berberis nervosa	Oregon grape
CHNO	Chamaecyparis nootkatensis	Alaska yellow cedar
CHUM	Chimophilla umbellata	Pipsissewa
COCA	Cornus canadensis	Dogwood
GASH	Gaultheria shallon	Salal
GYDR	Gymnocarpum dryopteris	Oak fern
LIBO	Linnaea borealis	Twinflower
MEFE	Menzeisia ferruginaea	False Huckleberry
OPHO	Oplopanax horridum	Devil's club
PICO	Pinus contorta	Lodgepole pine
POMU	Polystichum munitum	Swordfern
PSME	Pseudotsuga menziesii	Douglas fir
PYSE	Pyrola secunda	Pyrola
RHAL	Rhododendron albiflorum	Rhododendron
RULA	Rubus lasiococcus	Dwarf bramble

Table 6. (cont.)

Abbreviation	Scientific name	Common name
RUPE	Rubus pedatus	Blackberry
RUSP	Rubus spectabilis	Salmonberry
THPL	Thuja plicata	Western redcedar
TITR	Tiarella trifoliata	Trefoil foamflower
TIUN	Tiarella unifoliata	Coolwort
TSHE	Tsuga heterophylla	Western hemlock
VAAL	Vaccinium alaskaense	Ak. blueberry
VAME	Vaccinium membranaceum	Big whortleberry
VAOV	Vaccinium ovalifolium	Ovalleaf whortleberry
VAPA	Vaccinium parvifolium	Red whortleberry
VASI	Valeriana sitchensis	Sitka valerian
VISE	Viola sempervirens	Evergreen violet
XETE	Xerophyllum tenax	Beargrass

Spring Range

The Crystal Village spring range lies at approximately 1180 m MSL. Only four habitats constituted this spring range: mid-age clearcuts, young clearcuts, old-growth, and old clearcuts (Table 7). The percentage of mid-age clearcuts and young clearcuts in the home range was greater than occurred in the valley. Old clearcuts and old-growth were less common than in the valley. Due to errors in habitat identification, results from 1983 habitat use within the home range are unusable. Within the home range in 1984, elk preferred mid-age clearcuts. Ninety seven percent of all locations were in this vegetation type. Elk avoided other vegetation types.

Gold Hill elk selected a spring range that coincided with the winter range. A greater proportion of old-clearcut and alder flat habitats was found in their home range than in the valley (Table 7). Within the home range, elk selected old-clearcuts and avoided alder flat habitats.

North Boundary elk remained on their winter range during spring, but the average elevation of the home range increased 100 feet to 975m MSL. All habitats except old-clearcuts and alder were overrepresented in the home range compared to the valley. Within the home range, elk preferred the valley bottom habitats, as in winter. The upstream movement is reflected in the selection of the higher elevation Abam/Vaal habitat type (Table 7).

Table 7. Availability and use of habitats within the watershed and composite home ranges of elk in spring, 1983 and 1984.

	Spring Range Cover Type	% in Watershed	Composite 1983 Home Range % Available	% Use[a]	(n)	Composite 1984 Home Range % Available	% Use[a]	(n)
Crystal Village	Old Clearcut	35.2	6.8			10.3	1.5-	
	Old-growth	31.9	18.6			10.6	0.0	
	Mid-age Clearcut	9.7	49.2		6	46.6	97.0+	7
	Young Clearcut	7.2	25.4			32.6	1.5-	
Gold Hill	Old Clearcut	35.2	63.7	96.4+		63.7	84.2	
	Old-growth	31.9	1.2	0.0		1.2	5.2-	
	Alder	3.7	30.1	3.6-	2	30.1	10.5	2
	Cottonwood Mix	0.5	1.9	0.0		1.9	0.0	
	Open Swampy Meadow	1.0	2.8	0.0		2.8	0.0	
North Boundary	Old Clearcut	35.2	5.0	1.2				
	Alder	3.7	1.5	2.5				
	Abam/Bene[b]	< 1.0	31.9	8.8+				
	Abam/Tiun	3.7	16.7	36.3+				
	Tshe/Gash	4.4	28.3	26.3+				
	Abam/Vaal	< 1.0	5.9	15.0+	4			
	Abam/Gash	< 1.0	3.4	1.2				
	Abam/Opho	< 1.0	1.5	5.0				
	Abam/Rhal	< 1.0	1.4	1.2				
	Abla/Vasi	< 1.0	3.0	0.0				
	Rula	< 1.0	< 1.0	1.2				

[a] This value indicates preference (+), no selection, or avoidance (-), based on use vs. availability comparison using a Bonferonni Z interval.

[b] Scientific and common names of abbreviations found in Table 6.

Summer Range

The average elevation for the summer home range of Crystal Village and Gold Hill elk was approximatley 1677m MSL. Within the home range, elk selected the Abla/Vasi habitats during 1983 (Table 8). Additionally, elk used Dry Grass and Lush-low herbaceous habitats more than availability, although those differences only approached significance. Elk avoided Abam/Bene, did not use Rock habitat, and used other habitats in proportion to their availability.

The average elevation of the North Boundary home range was approximately 1341m MSL. Fifty-two percent of the locations for the North Boundary herd were in the Abam/Bene habitat in 1983 and 89% in 1984, yet this habitat was not selected, reflecting its great availability within the home range (Table 8). Elk preferred the Alsi (*Alnus sinuata*) vegetation type in 1983 and used them in greater proportions than availability in 1984. Low-lush herbaceous habitats were avoided and all other habitats were used in proportion to availability.

Table 8. Availability and use of summer range habitats.

	Summer Range Cover Type	Composite 1983 Home Range % Available	% Use[a]	(n)	Composite 1984 Home Range % Available	% Use[a]	(n)
Gold Hill Crystal Village	Abla/Vasi[b] .	24.6	35.4		19.5	34.3+	
	Abam/Bene	24.2	13.6-		36.7	23.2-	
	Dry Grass	11.9	19.1		7.2	16.2	
	Shrub	5.8	2.7	8	6.8	5.5	9
	Low-lush herb.	5.5	5.4		3.5	12.1	
	Rock	3.6	0.0		2.5	0.0	
	Lush herbaceous	2.3	0.0		0.4	1.0	
	Alsi	0.6	0.7		0.4	0.0	
	Open subalpine forest	21.6	20.4		18.5	7.1	
North Boundary	Abam/Bene	73.7	52.0-		85.6	88.5	
	Open subalpine forest	8.3	20.4+		2.3	0.0	
	Lush herbaceous	6.3	5.1	3	3.2	0.0	3
	Rock	5.6	1.0		4.2	0.0	
	Dry Grass	1.9	2.0		0.8	0.0	
	Shrub	1.8	0.0		N/A		
	Alsi	1.7	19.4+		2.2	11.5	
	Low-lush herbaceous	0.9	0.0		1.0	0.0	

[a] This value indicates preference (+), no selection or avoidance (-), based on use vs. availability comparison using a Bonferonni Z interval.

[b] Scientific and common names of abbreviations found in Table 6.

Movements and Home Range Size

Because only two radio-collared elk existed in the Gold Hill herd, which merged with the Crystal Village herd during summer, data from those two herds were pooled for analyses of movements and home range. On winter range, elk in the Crystal Village and Gold Hill herds moved significantly greater distances each day than did elk in the North Boundary Herd (Table 9). Average daily movements of elk increased from winter to spring for each herd, and declined during summer. There were no significant differences in daily movements between herds during spring. Crystal Village elk moved significantly more than North Boundary elk during the summer.

During winter, home ranges (minimum convex polygon) of elk were smaller in the Crystal Village herd than in the North Boundary herd (Table 10). The average size of home range of Gold Hill and Crystal Village elk decreased during spring, and increased during summer. Home ranges of elk in the North Boundary herd remained constant throughout the year.

Table 9. Means[e] (± Standard deviatons) of Average Daily Movement (in meters) for elk in each home range.

Herd	n	Winter	Spring	Summer
Crystal Village	9	161 a (± 83.7)	449 b (± 212.1)	309 b (± 151.2)
North Boundary	4	99 c (± 24.6)	405 db (± 174.6)	164 c (± 38.2)
Gold Hill[f]	2	124 ac (± 50.6)	188 d (± 43.0)	

(e) Values with common superscripts are not statistically different $(p>.05)$ than other values in the same row or column.

(f) Gold Hill Herd joined the Crystal Herd for the summer.

Table 10. Mean home range size[e] (± Standard deviation) for individual elk (measured by minimum convex polygon) on each home range, in km^2.

Herd	n	Winter	Spring	Summer
Crystal Village	9	5.39 a (± 3.5)	2.75 b (± 1.7)	8.72 a c (± 5.9)
North Boundary	4	13.72 c (± 8.49)	13.65 c (± 7.7)	13.02 c (± 6.8)
Gold Hill[f]	2	11.45 a c (± 11.4)	8.50 b c (± 8.6)	

(e) Values with common superscripts are not statistically different ($p > .05$) than other values in the same row or column.

(f) Gold Hill Herd joined the Crystal Village Herd for the summer.

Social Group Interactions

Radio-collared elk within herds were rarely within 400 m of each other during winter. Average distances between elk in the Crystal Village herd during winter (2126 m) were significantly greater than between members of the North Boundary Herd (1396 m) (Table 11). Average distances between elk in the Crystal Village herd and Gold Hill herd decreased by almost half during spring (935 m and 774 m, respectively) (Table 11), and increased again in summer (1834 m for both herds). Average distances between the North Boundary elk were smallest during winter and summer (951 m and 905 m, respectively) but were very large during spring (4772 m).

Table 11. Mean seasonal distance(d) (± Standard deviation) in meters[e] between radio-collared elk, and coincidence indices (CI).

Herd		Winter		Spring		Summer	
	n	d	CI	d	CI	d	CI
Crystal Village	9	2126(a) (±851)	.039 (±.08)	935(c) (±533)	.244 (±.14)	1834(a) (±1014)	.114 (±.122)
North Boundary	4	951(b) (±307)	.05 (±.049)	4772(a) (±2664)	.027 (±.046)	905(b) (±439)	.274 (±.243)
Gold Hill[f]	2	1396(a) (±224)	.107 (±.151)	774(c) (±259)	.324 (±.211)		

(e) Values with common superscripts are not significantly different (p>.05) than other values in the same row or column.

(f) Gold Hill Herd joined the Crystal Village Herd during the summer.

V. DISCUSSION

Migration

Heavy snowfall probably stimulated elk to migrate off the summer range. Schroer (1986) found that Roosevelt elk in Olympic National Park migrate to lower elevations in response to the first major storm of autumn. Lovaas (1970) suggested that where parks offered refuges from hunting, elk delayed migration from these areas until driven out by snow. In both years of this study, elk migrated to their winter range within two days of the first snow accumulation deeper than 18 inches on summer range (1524m MSL). Snow depth greater than 18 inches covers forage and makes movement difficult (Leege and Hickey 1977), and it may be energetically more efficient to move onto the winter range.

Elk used river corridors as migration routes. After autumn storms, elk moved immediately down the sideslopes of the White River and Huckleberry Creek drainages, then travelled down the river corridors to winter range. Elk concentrated in these two drainages during fall migration. However, when hunting season coincides with migration, hunting pressure may force elk back up snow covered ridges. Very heavy snows during the hunt could concentrate elk within the valley bottoms resulting in greater harvests.

Upward spring migration is probably in response to forage availability and quality. Migratory elk follow the snowmelt upward, grazing on new, succulent forage (Compton 1975, Ward

1973, Janz 1980). Forage was just emerging in the early-seral communities within the Crystal Village spring range when forage was becoming coarse on winter range, and had not yet emerged on summer range. As snow on the summer range melted, elk began migrating to these subalpine areas. North Boundary elk had no separate spring home range, but did arrive on the summer range coincident with snowmelt and forage emergence. Both herds followed the new emergence of forage during migration.

Elk tend to return to their same home range year after year (Murie 1951, Brazda 1953). Elk in this study used the same home ranges and migration routes for two years. This suggests that habitual behavior is an important determinant to elk migration.

Habitat Use Patterns

Roosevelt elk occur in a wide variety of habitats throughout western Oregon and Washington, demonstrating a high degree of plasticity in habitat selection. Witmer (1982) found that elk exhibited preferences for old-growth forest and hardwood stands over mixed forests and dense, young conifer stands, and that brushy clearcuts were used more than new clearcuts for foraging. Smithey *et al.* (1982) found that population densities of elk were related to availability of old-growth. On Vancouver Island, Janz (1980) found that wintering elk used 4-10 year old clearcuts most of the time, but also preferred old-growth. Jenkins (1980) studied sedentary elk in the Hoh River Valley, Washington, that remained in old-growth valley bottoms year-round. Schoen (1977) determined that elk in the Cedar River watershed, two drainages north of the White River, preferred young clearcuts and mesic areas but avoided old-growth in the winter. Schroer (1986) studied elk in the Duckabush-Dosewallips drainages of Washington and found that elk preferred young seral deciduous (alder) flats on the valley floor in the winter. Hanley (1984) reported that elk preferred mesic habitat patches in winter.

Of the different levels of habitat selection described by Johnson (1980), I studied two that occur among elk in the White River: selection of a home range within a landscape and habitat selection within a seasonal home range. During winter elk chose home ranges in bottomland riparian areas, but were generally non-selective of habitat within home ranges. Jenkins (1980), Schoen (1977), and Irwin and Peek (1976) also found that elk prefer bottomland for winter home range placement. In the White River, bottomlands were used heavily by elk in both an unmanaged, primarily old-growth ecosystem, and in a managed second-growth ecosystem in winter despite human acitivity and development that occured there. Those results corroborate the importance of bottomland riparian areas for Roosevelt elk in the western Cascades.

There has been considerable interest recently on the influence of post-logging succession on elk habitat qualities (Witmer et al. 1985). Generalized successional schemes usually depict a pulse of forage production after logging, followed by a lengthy non-productive period of second-growth succession. However, old clearcuts in the riparian areas of the White River

Valley are atypical. Even though 20-30 years old, they retained much of their heterogeneity, and the canopy remained open. A mosaic of open grassy or shrubby areas and dense foliage provided good hiding cover (vegetation capable of hiding a standing elk at 200 yards Thomas et al. 1979), as well as forage (vegetated areas with less than 60 percent canopy closure of trees and tall shrubs over 7 feet). Small openings in mesic bottomlands have persisted thus far during secondary succession, and appear to be long-lived seral communities. Very wet soil and heavy elk use hampered tree regeneration on these grass and sedge dominated meadows in the White River Valley. Grasses and sedges received heavy use during the winter and appeared to be important forage. Mesic alder habitats here also provide good hiding cover and, in certain areas, shrubby or herbaceous foraging areas. Leslie (1985) found that abscissed red alder leaves in the Hoh River of Olympic National Park contained high amounts of protein in the autumn. The high protein content of red alder leaves may attract Crystal Village elk to this habitat in the fall. Also, as early as late February, elk were observed foraging on new grass growth in alder flats.

Elk in the managed segment of the White River did not prefer optimal cover produced by old-growth forests. Optimal cover is defined as a forest stand with: 1) four layers (overstory canopy, sub-canopy, shrub layer, and herbaceous layer); and 2) an overstory canopy which can intercept and hold a substantial amount of snow yet has small (1/8th acre) openings (Witmer 1985). Lack of a snow-blocking canopy was not important during the mild winters of this study. Elk preferred to stay in the mesic bottomlands rather than use less productive and often snow covered sideslopes where the old-growth existed. However, old-growth may be an important component of managed habitat for providing shelter during severe winters. Snow accumulation never exceeded one foot during the study period and did not seem to affect elk movements. But snow depths greater than 6 feet accumulated in 1948-49 and in 1949-50 (Table 1). Under similar snow conditions, forage on the present winter range would become unavailable, and movement difficult. This could result in heavy mortality among elk.

Habitat use within spring ranges varied among herds in this study. Increased use of old clearcuts on the Gold Hill spring range may be due to better hiding cover in these habitats during birth and lactation. The Gold Hills area is a popular recreational site for campers and off-road vehicle users, and during crowded weekends the cows retreated to the most dense old clearcuts away from roads. Mid-age clearcuts on the Crystal Village spring range had an open canopy and produced succulent forage relative to the winter range during spring. Nutritional requirements for cow elk are at their greatest during lactation (Nelson and Leege 1982), so adequate or better forage quantity and quality may increase the health of cows and survival of calves. This may be reflected in the relatively high summer calf/cow ratios that were observed (i.e. 54-61/100 in 1983 & 1984, respectively) (Cooper 1985). Calf/cow ratios of Roosevelt elk on the west side of Olympic National Park have been reported to be 35-45 calves/100 cows in the summer (Jenkins 1981).

North Boundary elk did not shift from use of old-growth valley bottom forests during the spring. They did move upstream toward their summer range, consequently using the higher elevation Abam/Vaal habitat more. Foraging by elk in small avalanche clearings was noted during the spring. But these habitats were too small to determine from telemetry if radio-collared elk were within them. It is possible that more abundant forage growth in these mesic, open-canopy sites was used heavily in the spring.

The preferred Abla/Vasi habitat on summer range consists of a parklike scattering of subalpine fir growing in the basins and lower sideslopes of the summer range. A dense herbaceous layer in this habitat and in the adjacent meadow habitat provided abundant forage, and subalpine firs provided adjacent hiding and thermal cover. The preferred Dry Grass habitats were found just above and in the understory of Abla/Vasi habitats (Henderson 1974), and are usually the first to melt out in the spring. Migrating elk arrived here first and followed patches of early growth after snowmelt. This may explain the concentration of trailing and wallowing (Bradley 1982). On the North Boundary summer range, elk used the Abam/Bene habitat more than any other habitat, but only in proportion to its availability. The adjacent mesic alder slide areas produce succulent forage throughout the summer. Elk may have used the Abam/Bene habitat for thermal cover during the day when most locational data were gathered, and foraged in the alder slide habitat during crepuscular hours.

Movements and Home Range Size

In this study, home ranges were smaller on silviculturally managed winter ranges (x=5.4 km^2) than in unmanaged ranges (x=13.7 km^2). Those values were generally larger than estimates from other elk populations in managed (1.04 km,^{2} Witmer 1982; 2.59 km^2, Graf 1955) and unmanaged populations (7.5 km^2, Jenkins 1980) in the Pacific Northwest. Regional differences in habitat productivity may account for differences in home range sizes. Managed forests studied by Witmer (1982) contained a larger proportion of productive mid-age clearcuts than was found on the winter ranges in the White River. Additionally, old-growth rain forest valleys studied by Jenkins (1980) are characterized by open overstory canopies and productive herbaceous understories (Franklin and Dyrness 1973) compared to dense forest vegetation types in the old-growth of the White River valley (Franklin et al. 1979). Larger home ranges on unmanaged forests than on managed forests has been reported previously in the Pacific Northwest: this appears to be due to the more dispersed forage base in old-growth forests (Jenkins and Starkey 1982) than in clearcut areas.

Mean daily movements of elk were greater on managed than on unmanaged winter range in the White River valley, although home ranges were smaller on the managed winter ranges. Elk in the managed forests apparently moved more often each day within a smaller seasonal home range. Human disturbances may increase elk daily movements while home ranges that contain a relatively concentrated forage base could explain small home ranges in the managed habitat.

Daily movements and size of home ranges varied seasonally for elk that wintered on managed forests but not for those wintering on unmanaged ranges. In general, home ranges were smallest during spring, while daily movements were greatest. Hanley (1982) suggested that elk in the Cedar River watershed move more during June to use an increase in high quality forage, which was widely and abundantly distributed. The North Boundary spring range may be larger than managed spring range because of a less pronounced increase in forage production in the old-growth forest.

In this study, large summer ranges (8 - 13 km^2)in the subalpine zone conflict with findings of other studies. Harestaad and Bunnell (1979) stated that animals living in a habitat of higher productivity will have smaller home ranges. Witmer (1982) found small home ranges (1.1 km^2) for elk summering in managed forests which produced abundant forage. Schroer (1980) found home ranges in the productive subalpine areas of the Olympic Mountains to be smaller than winter ranges in the managed lowlands. To the contrary, Harestaad and Bunnell (1979) suggested that where there is not abundant summer forage one would expect home ranges to be larger. Jenkins (1980) found that sedentary elk in the Hoh River had large summer ranges. These elk remained in stable unmanaged old-growth forests during summer. Assuming subalpine summer habitats in this study are more productive than winter habitats, Harestaad and Bunnell's (1979) hypothesis would predict that summer home ranges should be smaller than winter ranges. In this study, subalpine summer home ranges were largest of the seasonal ranges and large relative to other studies. Elk seemed more sensitive to human disturbance on the summer range than on the winter or spring range, and would often run more than 1 km in response to hikers. Large movements due to human disturbance may have enlarged the summer home ranges.

Social Group Interactions

Previous studies conducted in the Pacific Northwest suggest that elk in managed forests form less cohesive social units than elk in stable habitats such as unmanaged forests. Geist (1974) stated that the use of stable, self-regulating, climax plant communities by ungulates selects for high cohesion and gradual mother/young disassociation whereas changing seral habitats select for juvenile dispersal. Presumably, juvenile retention and the development of stable social bonds benefits elk in stable habitats by enabling them to learn the intricacies of seasonal movements and habitat use from their mothers over a long period of time. Franklin (1979) found that elk in stable habitats at Prairie Creek State Park were relatively cohesive, as did Jenkins (1980), who studied elk in undisturbed old-growth forests of the Hoh River in Washington. In contrast, Harper (1964) reported that non-migratory elk in silviculturally managed forests of southwest Oregon changed herd composition continually; elk from neighboring groups interchanged, and elk herds were generally unstable. Schoen (1977) found elk in the silviculturally managed

Cedar River watershed, Washington, did not form stable and cohesive social groups. Jenkins and Starkey (1982) suggested that juvenile dispersal and less cohesion among adults may be favored where logging creates transient, yet very productive, subclimax habitats.

In this study coincidence indices for elk in unmanaged and managed forests were low compared to herds in stable habitats of the Olympic peninsula (Jenkins 1980) or Prarie Creek State Park (Franklin 1979). Average distances between pairs of elk in this study were also relatively large: indicating very low cohesion. Migration displaces individuals and mixes unrelated family groups (Franklin and Lieb 1979) and may account for low cohesion in the Mount Rainier area. Also, elk populations have only recently colonized the Mount Rainier ecosystem (Schullery 1984). Franklin (1975) suggests that young colonizing populations are in a less stable phase of group development and thus would have lower cohesion than older, stable populations. It may be more appropriate to refer to herds such as these at Mount Rainier as feeding aggregations (Wilson 1975) or herd units (Edge 1986) rather than calling them herds, which connotes social cohesiveness.

Larger average distances between pairs of elk on managed winter range than on unmanaged winter range may not be due to differences in social stability since elk in neither herd form cohesive social groups. Rather, the difference may be due to topography and human disturbance. Crystal Village and Gold Hill winter ranges lie on a broad floodplain that elk are free to roam over with relatively high human disturbance and development.

North Boundary elk winter range is within a steep, narrow 1/4 - 1/2 mile wide flooodplain, that restricts elk movement.

During the spring, average distance between animals in the managed forests decreased from winter to spring by almost one-half. Cows dispersed and gave birth on the winter range, then formed tight, multiple cow - calf groups on the spring range. This is a common behavioral characteristic of elk (Geist 1982), and would explain higher social cohesion in the spring. Elk in the old-growth during spring were less cohesive than in the winter, and less cohesive than elk in the managed forests during spring, perhaps because these elk had no distinguishable spring range; they slowly but separately wandered upstream toward their summer range.

Average distances between pairs of elk during the summer for both Crystal Village (1834 m)and the North Boundary elk (905 m) are not significantly different than winter values (2126 m & 951 m, respectively). This suggests that although these herds are not tightly associated, elk apparently move as loose aggregations or social groups during migration. More disturbance from hikers in the Crystal Village summer range than on the North Boundary summer range may be why herds are more loosely associated on the Crystal Village summer range than on the North Boundary summer range.

VI. CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Identification of migratory herd units and their seasonal home ranges in this study allows for subsequent assessment of forage productivity and nutrient analysis, cover requirements, and human disturbance on elk populations. Several techniques have been designed to ameliorate the impacts of timber sales and road management affects on elk populations (Thomas 1980, Witmer et al. 1986, Leege 1984, Lyon et al. 1985). Use of these guidelines implies a knowledge of herd unit boundaries. Often areas to be evaluated as elk range are chosen arbitrarily or on the basis of agency administrative boundaries. Rather, they should be chosen to represent the herd unit being impacted. This would allow elk management activities to be targeted at specific herds. It must also be realized that elk use these herd units during specific times of year. Management activities must correspond to seasonal movements. For instance, providing calving areas on the summer range would be of no benefit, and logging activities on the calving range should be curtailed during parturition and early lactation.

Also, knowing the location and use period of fall elk ranges allows effective management of hunting seasons and boundaries. This would be especially valuable for planning controlled hunts to reduce populations of specific summer populations within Mount Rainier National Park.

Despite differences in land management on the Crystal Village and the North Boundary ranges, both herds selected mesic, river bottom sites. Mesic areas have been found to be important winter habitats in other areas (Schoen 1979, Janz 1980, Schroer 1986). These winter ranges are critical for elk, yet are subject to great disturbances from humans, such as logging, roads, housing, and recreation. Logging practices may have the largest effect on elk winter range in western Oregon and Washington. In this study elk preferred old clearcuts and alder habitats on the managed winter range, both of which occurred in wet areas. The old clearcuts in the Crystal Village winter range are quite different from most clearcuts of this age. They are very heterogeneous with a good mixture of grassy or shrubby open patches. Much more forage grows in these old clearcuts than in most other similarly aged cuts where the canopy has shaded the understory. These riparian clearcuts have remained productive for a longer period than expected based on other studies. Thus, typical predictive models of elk response to silvicultural management may not apply to this winter range since contributions to elk forage in certain age classes differ from those observed in studies upon which the models have been developed.

To some extent, the future of elk populations is dependent on winter weather conditions. During the study, winters were mild, but severe weather with snows up to six feet deep could occur and would probably result in high mortality. A return to mild weather would allow recovery. Although prediction is difficult, elk populations will probably reach an equilibrium with the winter and spring habitat and be maintained there until the occurrence of a severe winter or seral changes on the winter range. Elk densities, then, will likely remain high for some time barring a severe winter in the near future.

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VIII. APPENDICES

APPENDIX 1

COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE VALUES

CRYSTAL VILLAGE SUMMER

1983

COHESIVENESS

450	451	454	455	458	459	464		AVERAGE DAILY MOVEMENT	MCP
2161 .118	2680 .043	2856 .00	2665 .00	2444 .00	1911 .039	2838 .00	448	268	7.5
	2324 .00	1198 .158	881 .250	1110 .182	956 .280	1591 .105	450	317	4.9
		3315 .00	2597 .00	3383 .00	2770 .00	1215 .177	451	458	33.4
			736 .214	534 .375	832 .211	1540 .231	454	242	9.3
				352 .471	782 .300	2624 .00	455	162	1.2
					867 .384	2703 .063	458	24	2.7
						1534 .211	459	223	6.4
							464	247	12.1

AVERAGE DISTANCE APART

COLE'S COEFFICIENT

1984

COHESIVENESS

448	450	451	454	455	459	464	469		AVERAGE DAILY MOVEMENT	MCP
3386 .00	1008 .222	3105 .00	1612 .00	1515 .154	283 .222	668 .316	141 .133	446	252	1.5
	1558 .125	1806 .00	2121 .00	2057 .148	2162 .125	1539 .261	2286 .069	448	291	18.7
		4381 .00	1384 .174	1093 .174	1254 .214	477 .276	2681 .000	450	405	7.3
			3306 .00	4937 .00	2989 .00	3036 .00	2059 .00	451	599	19.2
				✡	1629 .00	1197 .00	1020 .00	454	459	14.9
					1294 .174	1390 .167	781 .00	455	111	1.5
						904 .207	1228 .00	459	312	8.0
							1830 .00	464	355	6.4
								469	508	29.4

MCP means MINIMUM CONVEX POLYGON size in km square

other meas. in m.

CRYTSAL VILLAGE SPRING

1983

COHESIVENESS

450	451	455	458	459		AVERAGE DAILY MOVEMENT	MCP
1415 .191	579 .303	2338 00	1418 .080	1251 .182	448	868	4.3
	1453 .129	1732 .222	1038 .167	1350 .285	450	805	4.2
		1944 .105	1087 .229	1065 .250	451	351	4.9
			1568 .194	1777 .071	455	275	1.4
				974 .240	458	682	5.8
					459	281	4.0

1984

COHESIVENESS

448	450	451	455	459	469		AVERAGE DAILY MOVEMENT	MCP
00 .333	382 .421	651 .240	955 .333	327 .556	608 .429	446	406	0.8
	322 .235	377 .095	443 .125	125 .571	1020 .167	448	168	0.8
		567 .286	650 .348	323 .381	402 .526	450	390	2.6
			747 .370	781 .160	592 .240	451	295	2.7
				1206 .100	630 .240	455	406	2.9
					640 .375	459	405	0.8
						469	505	1.4

AVERAGE DISTANCE APART

COLE'S COEFFICIENT

MCP means MINIMUM CONVEX POLYGON SIZE size in km square

other meas. in m.

CRYSTAL VILLAGE WINTER

1983

COHESIVENESS

AVERAGE DISTANCE APART
COLE'S COEFFICIENT

450	451	455	458	459		AVERAGE DAILY MOVEMENT	MCP
1853 .074	3555 .00	2056 .00	1517 .080	1267 .348	448	31	1.3
	2030 .167	1352 .276	1650 .00	2501 .00	450	78	5.0
		1685 .00	2363 .00	4154 .00	451	77	5.7
			941 .00	2749 .00	455	142	2.4
				2282 .00	458	152	2.4
					459	80	2.2

1984

COHESIVENESS

448	450	451	455	458	459	469		AVERAGE DAILY MOVEMENT	MCP
1856 .00	2245 .00	2984 .00	2227 .00	☼ .00	1008 .00	1992 .00	446	155	5.1
	2445 .042	3751 .00	2471 .00	1117 .063	1948 .044	1312 .00	448	200	4.2
		1925 .049	1034 .192	2970 .00	2526 .00	1296 .00	450	208	7.2
			1745 .049	2705 .00	3817 .00	2187 .069	451	226	11.5
				3526 .00	2740 .00	601 .158	455	206	6.4
					1238 .067	☼ .00	458	113	2.0
						1550 .00	459	249	12.6
							469	343	8.2

MCP means MINIMUM CONVEX POLYGON size in km square

other meas. in m.

NORTH BOUNDARY WINTER

1983

	461	465	AVERAGE DAILY MOVEMENT	MCP
444	1016 .046	767 .104	117	17.8
461		1185 .046	91	4.4
465			67	6.9

1984

	444	461	465	AVERAGE DAILY MOVEMENT	MCP
443	1341 .00	356 .132	1110 .00	140	16.1
444		1101 .00	638 .094	98	28.4
461			1047 .041	101	5.8
465				76	13.7

NORTH BOUNDARY SPRING

	444	461	465	AVERAGE DAILY MOVEMENT	MCP
443	6453 .00	867 .11	7979 .00	269	16.1
444		4124 .00	2783 .05	661	23.1
461			6432 .00	353	5.1
465				336	10.3

NORTH BOUNDARY SUMMER

1983

	461	465	AVERAGE DAILY MOVEMENT	MCP
444	524 .400	529 .340	177	15.8
461		877 .67	171	8.9
465			198	23.1

1984

	461	465	AVERAGE DAILY MOVEMENT	MCP
444	980 .125	1717 .057	157	7.4
461		805 .054	92	5.8
465			190	17.3

AVERAGE DISTANCE APART
COLE'S COEFFICIENT

MCP means MINIMUM CONVEX POLYGON size in km square

other meas. in m.

GOLD HILL WINTER

1983

COHESIVENESS

	464
454	1237 .00

	AVERAGE DAILY MOVEMENT	MCP
454	96	1.3
464	87	2.3

1984

	464
454	1554 .213

	AVERAGE DAILY MOVEMENT	MCP
454	116	18.3
464	198	24.0

GOLD HILL SPRING

1983

COHESIVENESS

	464
454	590 .473

	AVERAGE DAILY MOVEMENT	MCP
454	166	3.0
464	146	2.5

1984

		464
AVERAGE DISTANCE APART	454	957
COLE'S COEFFICIENT		.174

	AVERAGE DAILY MOVEMENT	MCP
454	196	21.1
464	245	7.8

MCP means MINIMUM CONVEX POLGON size in km square

other meas. in m.

APPENDIX 2

STATISTICAL TESTS FOR DIFFERENCES BETWEEN YEARS IN COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE

DIFFERENCE BETWEEN YEARS
FOR
COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE (MCP)

NORTH BOUNDARY SUMMER

	DIFFERENCE ('83 - '84)	T VALUE
COH	-524 m	.4781 ns
ADM	36 m	.5419 ns
MCP	5.8 km2	1.268 ns

DIFFERENCE BETWEEN YEARS
FOR
COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE (MCP)

NORTH BOUNDARY WINTER

	DIFFERENCE ('83 - '84)	T VALUE
COH	61 m	.2775 ns
ADM	-0.2 m	.0058 ns
MCP	-6.25km2	.7760 ns

DIFFERENCE BETWEEN YEARS
FOR
COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE (MCP)

GOLD HILL WINTER

	DIFFERENCE ('83 - '84)	T VALUE
COH	*	only 2 values - can not test
ADM	-65 m	.7144 ns
MCP	-19.31km2	4.14 ns

DIFFERENCE BETWEEN YEARS
FOR
COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE (MCP)

GOLD HILL SPRING

	DIFFERENCE ('83 - '84)	T VALUE
COH	*	only 2 values - can not test
ADM	-64 m	.9348 ns
MCP	-11.78km2	.9338 ns

DIFFERENCE BETWEEN YEARS

FOR

COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE (MCP)

CRYSTAL VILLAGE WINTER

	DIFFERENCE ('83 - '84)	T VALUE
COH	-282 m	.0845
ADM	-107 m	.5377 ns
MCP	-4.11km2	.4560 ns

DIFFERENCE BETWEEN YEARS

FOR

COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE (MCP)

CRYSTAL VILLAGE SPRING

	DIFFERENCE ('83 - '84)	T VALUE
COH	936 m	.6019
ADM	183 m	.2251 ns
MCP	1.81km2	.4047 ns

DIFFERENCE BETWEEN YEARS

FOR

COHESIVENESS, AVERAGE DAILY MOVEMENT, AND HOME RANGE SIZE (MCP)

CRYSTAL VILLAGE SUMMER

	DIFFERENCE ('83 - '84)	T VALUE
COH	-389 m	.0947
ADM	-84 m	.3833 ns
MCP	-0.17km2	.0081 ns

APPENDIX 3

PREFERENCE - AVOIDANCE VALUES FOR EACH HOME RANGE

HABITAT USE
ON
GOLD HILL SPRING RANGE 1983

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #		POOLED DATA Lev.1	Lev.2	%	% Avail. Home rng.	% Avail. Valley
	454	464					
1a	25 +	28 +	+	+	96.4	63.7	35.2
3a	2 -	0 -	0	-	3.6	30.1	3.7
7a	0 -	0 -	-	-	0	2.8	1.0
6a	0 -	0 -	-	-	0	1.9	0.5
2a	0 -	0 -	-	-	0	1.2	31.9
TOTAL	27	28					
		Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
GOLD HILL SPRING RANGE 1984

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #		POOLED DATA Lev.1	Lev.2	%	% Avail. Home rng.	% Avail. Valley
	454	464					
1a	7 0	9 +	+	0	84.2	63.7	35.2
3a	2 0	0 -	0	-	10.5	30.1	3.7
7a	0 -	0 -	-	-	0	2.8	1.0
6a	0 -	0 -	-	-	0	1.9	0.5
2a	1 0	0 -	-	-	5.2	1.2	31.9
TOTAL	27	28					
		Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
NORTH BOUNDARY WINTER RANGE 1983

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #			POOLED DATA Lev.1	Lev.2	%	% Avail. Home rng.	% Avail. Valley
	465	461	444					
11	0 -	1 0	3 -	+	-	6.0	40.8	#
17	3 0	7 0	6 0	+	+	23.9	15.7	3.7
29	16 +	1 -	9 0	+	+	34.3	11.2	4.4
18	0 -	9 +	1 0	+	0	14.9	8.7	#
03	0 -	0 -	0 -	-	-	0	6.5	1.8
12	2 0	0 -	3 0	+	0	7.4	6.0	#
19	0 -	0 -	0 -	+	-	0	4.0	#
21	1 0	0 -	1 0	0	0	3.0	1.4	2.2
14	1 0	1 0	1 0	+	0	4.5	1.0	#
15	0 -	0 -	1 0	+	0	1.5	0.6	#
16	0 -	0 -	0 -	+	0	0	.09	#
TOTAL	24	19	24					
			Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
NORTH BOUNDARY WINTER RANGE 1984

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #				POOLED DATA Lev.1	Lev.2	%	% Avail. Home rng.	% Avail. Valley
	465	444	461	443					
11	0 -	3 -	1 -	4 0	+	-	8.7	31.9	#
17	5 0	7 0	19 0	5 0	+	+	31.5	11.8	3.7
29	10 0	15 +	0 -	0 -	0	-	11.9	28.1	4.4
18	2 0	1 0	4 0	1 0	+	+	8.7	5.9	#
03	0 -	0 -	0 -	0 -	-	-	0	3.9	1.8
12	0 -	5 0	0 -	0 -	+	0	5.5	3.4	#
16	1 0	0 -	1 0	0 -	+	0	2.2	3.4	#
21	0 -	0 -	1 0	1 0	0	0	2.2	1.5	#
14	1 0	0 -	2 0	0 -	+	0	3.3	1.5	#
28	0 -	0 -	0 -	0 -	+	-	0	1.5	#
15	1 0	1 0	0 -	0 -	+	0	0	1.5	#
20	0 -	0 -	0 -	0 -	+	-	0	1.0	#
01	0 -	0 -	0 -	0 -	+	-	0	0.4	#
19	0 -	0 -	0 -	0 -	+	-	0	0.2	#
13	0 -	1 0	0 -	0 -	+	0	1.0	0.1	#
TOTAL	20	33	28	11					
				Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat,
second figure is preference avoidance rating.

HABITAT USE
ON
NORTH BOUNDARY SUMMER RANGE 1983

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #						POOLED DATA Lev.2	%	% Avail. Home rng.
	461		444		465				
11	19	+	10	-	23	0	-	52.0	73.7
02	10	0	3	0	7	0	+	20.4	8.28
01	2	0	2	0	1	0	0	5.1	6.3
03	0	-	0	-	1	0	0	1.0	5.6
06	2	-	0	-	0	-	0	2.0	1.9
04	0	-	0	-	0	-	-	0	1.8
09	6	0	9	+	4	0	+	19.4	1.7
05	0	-	0	-	0	-	-	0	0.9
TOTAL	39		24		36				
						Chi2	*		

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE ON NORTH BOUNDARY SUMMER RANGE 1984

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #						POOLED DATA Lev.2	%	% Avail. Home rng.
	461		444		465				
11	18	0	14	0	14	0	0	88.5	85.6
02	0	-	0	-	0	-	-	0	2.28
01	0	-	0	-	0	-	-	0	3.2
03	0	-	0	-	0	-	-	0	4.2
06	0	-	0	-	0	-	0	0	0.8
09	1	0	2	0	3	0	0	11.5	2.2
05	0	-	0	-	0	-	-	0	1.0
TOTAL	39		24		36				

Chi2 *

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
NORTH BOUNDARY SPRING RANGE COMPOSITE

(Number of locations and preference-avoidance values)

HABITAT CODE	POOLED DATA Lev.1	Lev.2	%	% Avail. Home rng.	% Avail. Valley
11	-	+	8.6	31.9	#
17	+	+	35.8	16.7	3.7
29	0	+	25.9	28.3	4.4
18	0	+	14.8	5.9	#
12	0	0	1.2	3.4	#
14	0	0	4.9	1.5	#
15	0	0	1.2	1.4	#
20	+	-	0	0.1	#
1a	0	0	1.2	#	35.2
3a	0	0	2.5	#	3.7
26	0	0	1.2	#	#
Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance-rating.

HABITAT USE
ON
GOLD HILL WINTER RANGE 1983

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #		POOLED DATA			% Avail.	% Avail.
			Lev.1	Lev.2	%	Home rng.	Valley
	454	464					
1a	2 0	10 0	0	0	54.5	74.4	35.2
3a	0 -	3 0	0	0	13.6	14.5	3.7
7a	0 -	0 -	-	-	0	2.1	1.0
6a	0 -	0 -	-	-	0	1.6	0.5
2a	2 0	4 0	0	+	27.3	2.8	31.9
5a	1 0	0 -	0	0	4.5	4.5	7.2
TOTAL	5	17					
		Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
GOLD HILL WINTER RANGE 1984

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #				POOLED DATA Lev.1	Lev.2	%	% Avail. Home rng.	% Avail. Valley
	454		464						
1a	10	0	18	0	+	0	66.7	74.4	35.2
3a	4	0	2	0	0	0	14.3	14.5	3.7
7a	1	0	1	0	-	0	4.7	2.1	1.0
6a	0	-	0	-	-	-	0	1.6	0.5
2a	3	0	1	0	-	0	9.5	2.8	31.9
5a	1	0	1	0	0	0	4.8	4.5	7.2
TOTAL	19		23						
				Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
CRYSTAL VILLAGE WINTER RANGE 1983

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #						POOLED			% Avail. Home rng.	% Avail. Valley
	448	455	459	450	458	451	1	2	%		
4a	0 -	0-	0 -	2 0	1 0	1 0	0	1	4.1	13.9	9.6
2a	0 -	0-	1 0	2 0	3 0	3 0	-	0	9.3	14.1	31.9
3a	6 0	1 0	3 0	7 0	3 0	1 0	+	0	21.7	10.9	3.7
6a	3 0	0 -	0 -	2 0	0 -	0 -	0	0	5.2	1.8	1.0
7a	0 -	0 -	0 -	0 -	0 -	0 -	-	-	0	1.9	1.0
5a	0 -	0 -	0 -	0 -	0 -	0 -	-	0	2.1	2.1	7.2
8a	0 -	0 -	0 -	0 -	0 -	0 -	-	-	0	0.5	0.1
1a	4 0	14 +	6 0	14 +	15 +	3 0	+	0	57.7	45.0	35.2
TOTAL	14	15	10	27	22	10					
						Chi2	*	*			

means less than 0.1%

* means significant

1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
CRYSTAL VILLAGE WINTER RANGE 1984

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #																POOLED 1	POOLED 2	%	% Home rng.	% Valley
	459		446		448		450		451		455		458		469						
1a	17	0	7	0	14	0	18	0	8	0	23	0	5	0	6	0	+	0	70.0	63.3	35.2
4a	0	-	0	-	4	0	3	0	3	0	1	0	1	0	1	0	0	0	9.3	10.5	9.6
3a	2	0	0	-	6	0	0	-	0	-	2	0	1	0	3	0	-	0	10.0	9.3	3.7
2a	2	0	0	-	0	-	2	0	6	0	1	0	0	-	0	-	0	0	7.9	9.5	31.9
6a	1	0	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	0.7	2.5	1.1
7a	0	-	0	-	1	0	1	0	0	-	0	-	1	0	0	-	0	0	2.1	1.2	1.0
5a	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	3.3	7.2
8a	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	0.3	0.1
TOT.	22		7		25		24		17		27		8		10						
																Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
CRYSTAL VILLAGE SUMMER RANGE 1983
75% HARMONIC MEAN
(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #								POOLED DATA	%	% Home rng.
	464	459	448	451	454	455	458	450			
20	6 0	4 0	3 0	7 0	3 0	13 0	2 0	14 0	0	35.4	24.6
11	0 -	0 -	3 0	11 0	2 0	2 0	1 -	1 -	-	13.6	24.2
06	3 0	6 0	1 0	2 0	4 0	0 -	5 0	7 +	0	19.1	11.9
04	0 -	0 -	4 -	0 -	0 -	0 -	0 -	0 -	0	2.7	5.8
05	0 -	0 -	5 0	0 -	1 -	0 -	0 -	2 0	0	5.4	5.5
03	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-	0	3.6
01	0 -	0 -	1 0	0 -	2 0	0 -	0 -	1 0	0	0	2.3
09	0 -	0 -	0 -	1 0	0 -	0 -	0 -	0 -	0	0.7	0.6
02	4 0	15 +	0 -	0 -	0 -	0 -	11 0	0 -	0	20.4	21.6
TOTAL	13	25	17	21	12	15	23	25			
								Chi2	*		

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
CRYSTAL VILLAGE SUMMER RANGE 1984
75% HARMONIC MEAN
(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #								POOLED DATA	%	% Home rng.
	448	454	455	450	459	464	451	469			
11	2 -	1 0	2 0	2 0	2 0	4 0	8 0	2 0	-	23.2	36.7
20	10 +	2 0	2 0	6 0	6 0	3 0	1 0	4 0	+	34.3	19.5
02	1 0	1 0	1 0	1 0	1 0	0 -	0 -	2 0	0	7.11	18.5
06	0 -	2 0	1 0	2 0	3 0	5 0	1 0	2 0	0	16.2	7.2
04	0 -	0 -	1 0	1 0	1 0	2 0	0 -	0 -	0	5.5	6.8
03	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	-	0	2.5
05	3 0	1 0	2 0	2 0	1 0	1 0	1 -	1 0	0	12.1	3.5
01	1 0	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0	1.0	0.4
09	0 -	1 0	0 -	0 -	0 -	0 -	0 -	0 -	0	0	0.4
TOTAL	17	8	9	14	14	15	11	11	25		
								Chi2	*		

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
CRYSTAL VILLAGE SPRING RANGE 1983

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #						POOLED 1	2	%	%Home rng.	% Valley
	448	450	451	455	458	459					
4a	6 0	3 0	11 0	4 0	3 -	3 -	+	-	34.9	49.2	9.7
5a	2 0	4 0	2 0	2 0	3 0	3 0	+	0	18.6	25.4	7.2
2a	0 -	2 0	2 0	3 0	2 0	0 -	-	0	10.5	18.6	31.9
1a	3 0	1 0	7 +	8 +	7 +	5 0	0	+	36.1	6.8	35.2
TOT.	11	10	22	17	15	11					
						Chi2	*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.

HABITAT USE
ON
CRYSTAL VILLAGE SPRING RANGE 1984

(Number of locations and preference-avoidance values)

HABITAT CODE	ELK #														POOLED 1	POOLED 2	%	%Home rng.	% Valley
	446		448		450		451		455		459		469						
4a	7	+	5	+	11	+	16	+	10	+	9	+	7	+	+	+	97.0	46.6	9.7
5a	0	-	0	-	0	-	0	-	1	-	0	-	0	-	-	-	1.5	32.6	7.2
2a	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	10.6	31.9
1a	0	-	0	-	1	0	0	-	0	-	0	-	0	-	-	-	1.5	10.3	35.2
TOT.	7		5		12		16		11		9		7						
													Chi2		*	*			

means less than 0.1%
* means significant
1st column under "elk #" represents # of locations in habitat, second figure is preference avoidance rating.